



the iCub project

an open humanoid platform

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- rbcS (in short)
 - neuroscience
 - robotics
- robotics
 - iCub intelligence
 - iCub hardware
 - iCub software
 - iCub production

Cognitive Systems and Robotics in FP7 (2007-2012)

| Work Programme | Objective | Call (Evaluation) | Budget | Projects: ACS & Robotics (total) |
|------------------|---|--------------------|--------------|----------------------------------|
| 2007-2008 | ICT-2007.2.1 (ICT-2007.2.2): Cognitive Systems, Interaction , Robotics | ICT Call 1 (2007) | 96 M€ | 17 (27) |
| | | ICT Call 3 (2008) | 97 M€ | 17 (23) |
| 2009-2010 | ICT-2009.2.1: Cognitive Systems and Robotics *) | ICT Call 4 (2009) | 73 M€ | 19 |
| | | ICT Call 6 (2010) | 80 M€ | 22 |
| | FOF.ICT.2010.1: Smart Factories: ICT for Agile and Environmentally Friendly Manufacturing | NMP-ICT-FoF (2010) | 35 M€ | 3 (8) |
| 2011-2012 | ICT-2011.2.1: Cognitive Systems and Robotics | ICT Call 7 (2011) | 73 M€ | 16 |
| | | ICT Call 9 (2012) | 82 M€ | ?? |

*) No more interaction since 2009 - language-based interaction in a separate objective with its own budget

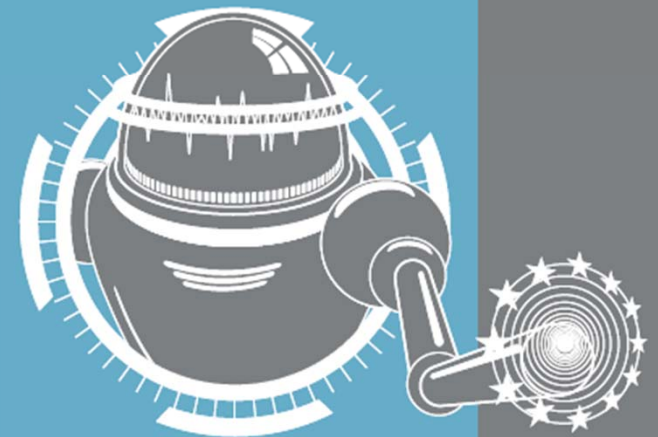


strategic research agenda for robotics in Europe

- RTD **strategy** document developed by EUROP members in the CARE project (FP6)
- **industry-driven**, based on extensive analysis of market development and future opportunities
- **commitment** of all European stakeholders
- short-term (2010), mid-term (2015) and long-term (2020) vision
- **public release** in Brussels on July 7, 2009

<http://www.robotics-platform.eu>

EUROP | EUROPEAN ROBOTICS
TECHNOLOGY PLATFORM



ROBOTIC VISIONS

TO 2020 AND BEYOND



SENSOR NETWORK/MONITORING/CONTROL INTELLIGENT BUILDING (iSense)

FOF – CustomPacker/Tapas/Robofoot

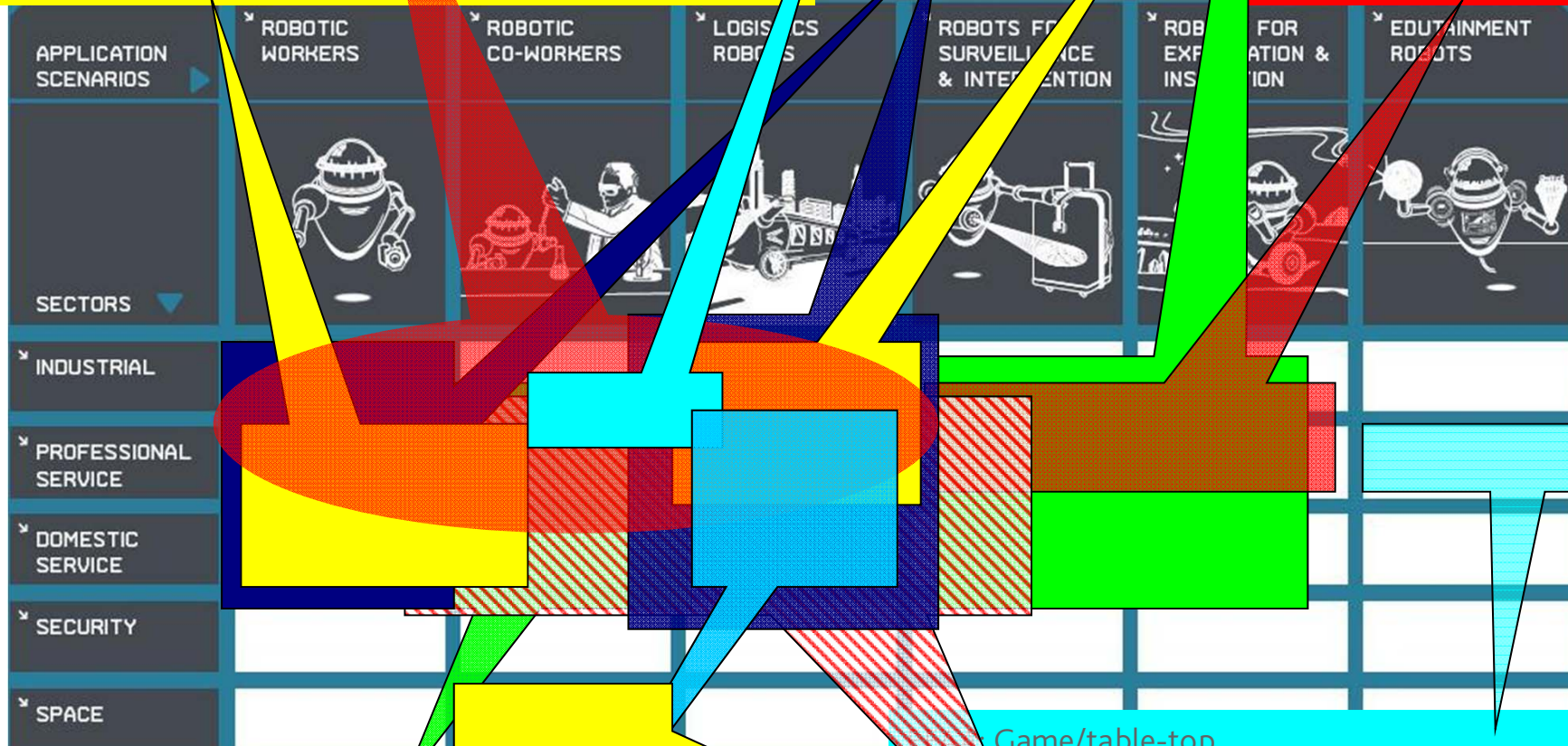
SURGICAL ROBOT (ACTIVE – I-SUR)

LOGISTICS (RobLog)

ROBOT BUILDER
(Goal-Leaders)

UNDERWATER
(NOPTILUS / CoCoRo)
Search& Rescue/
Unmanned (EMICAB)
UAV – ML (ComPLACs)

flexible object manipulation, packaging industry, medical applications
(eg prosthetic devices) (TOMSY)
Robot-arm/ML (ComPLACS)
Assembly (DARWIN/Intellact)



CORBYS: MOBILE MANIPULATION / eSMCS / CORBYS REHAB
Xperience: HOUSEHOLD HELPER
NeuralDynamics: HR COOPERATION TABLETOP – robotics and

VR of Space
manipulation(Intellact)

Game/table-top
IA – social HRI - Bar tender
computer animation
programming for Rehabilitation
SpaceBook: Navigation support

V-Charge: autonomous valet parking eCAR

RUBICON: assisted living /transport of goods

Call 7 outcome - S

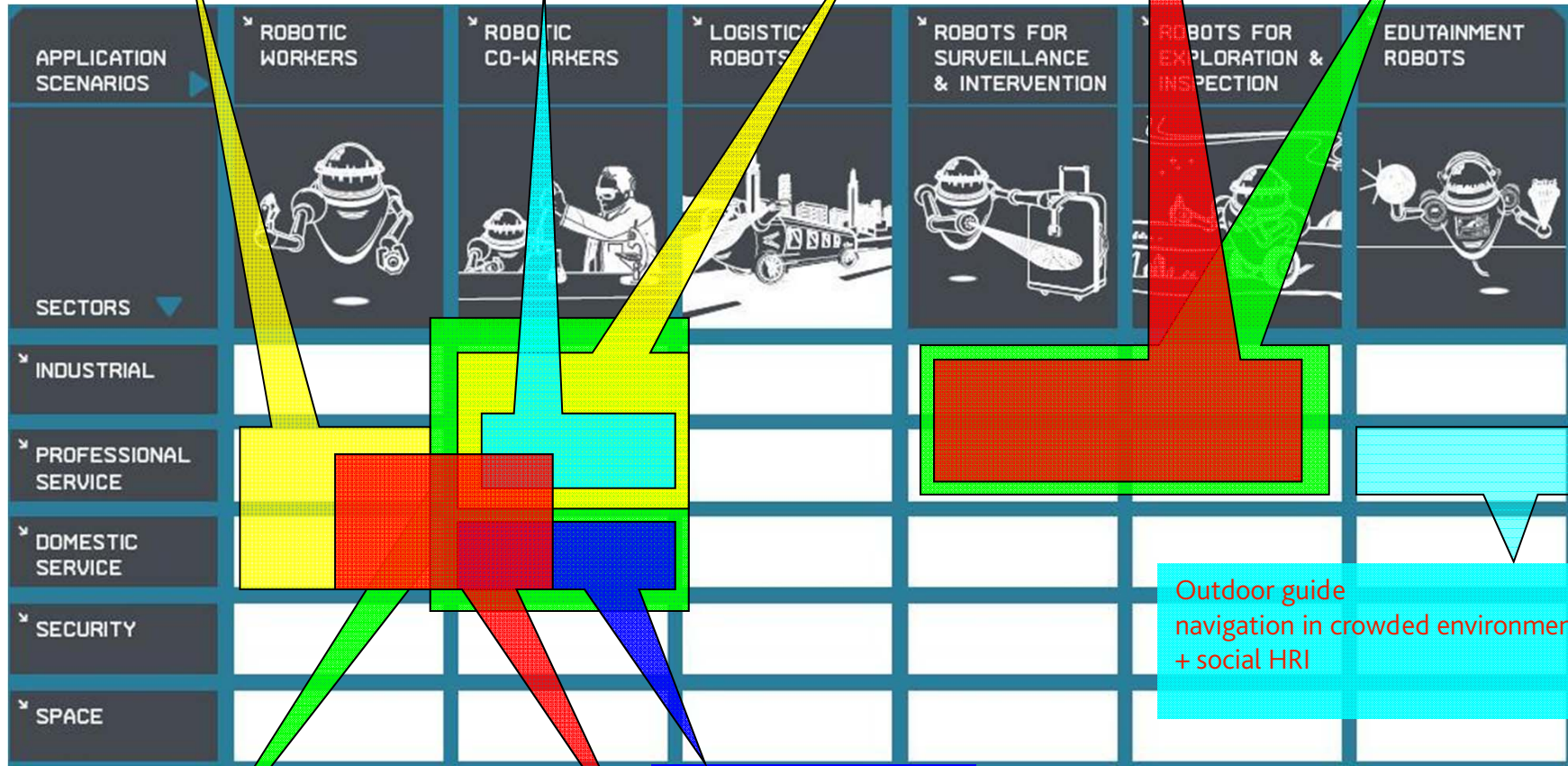
Underwater (cooperative/advanced autonomy)

Manipulation of deformable objects (folding/sorting clothes)
Mobile manipulation in a restaurant

Cognitive + Flexible robots
for SMEs manufacturing

Aerial cooperative manipulation

Assistive robotics surgery



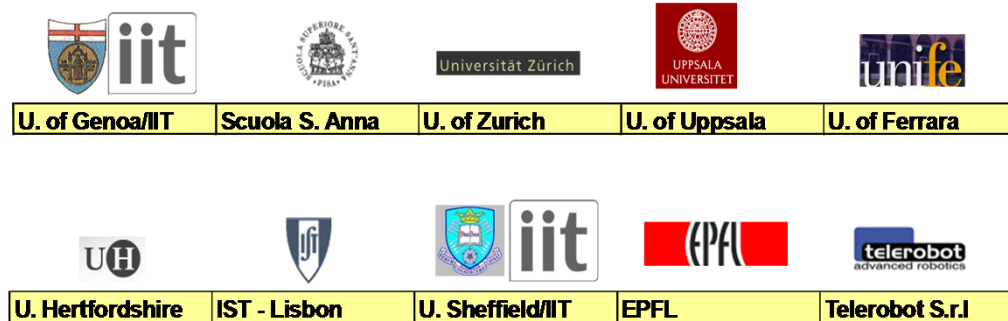
Outdoor guide
navigation in crowded environment
+ social HRI

Intelligent prosthesis

Object hand-over
Compliance & Modular design /assembly
Safe Physical HRI

Learning domestic tasks from web (cooking)
Understanding and carrying out everyday activity
(generalisation/learn action from spoken instruction/language-action link)

...a bit of (additional) history



- RobotCub (FP6): started 2004 – finished 2010, initial design
- ITALK: started 2008, extensions to language
- Poeticon: started 2008, supported the development of fingertips
- CHRIS: started 2008, supported the development of force control (for safety)
- RoboSKIN: started 2009, took over the development of a skin system
- Viactors: started 2009, study on intrinsic compliance and variable stiffness
- AMARSi: started 2010, compliance and learning, motor richness
- ImClever: learning and intrinsic motivations
- ROSSI: sensorimotor and social interaction
- Xperience: started 2011, cognitive architecture & affordances
- EFAA: started 2011, social interaction and learning from interaction
- Darwin: started 2011, manipulation and assembly
- Poeticon++: starting 2012, language and action

RobotCub goals

- ✓ design a **humanoid robot** platform, namely the iCub
 - ✓ make it the **platform of choice** for researchers in artificial cognitive systems
 - ✓ study **cognition** from a developmental perspective (neuroscience)
-



iCub community goals now

- ✓ maintain and improve the iCub to keep it alive
- ✓ make it the platform of choice for researchers in artificial cognitive systems
- ✓ study cognition from a multitude of points of view





iCub is an open source international endeavour initially funded by the EU project RobotCub

- a full **humanoid** robot
- is **104cm**, weighs **22 kg**
- has **53** degrees of freedom
- can **crawl, sit and manipulate**
- open design as **LGPL/GPL/FDL**



why is the iCub so special?



- **hands:** we started the design from the hands
 - 5 fingers, 9 degrees of freedom, 19 joints



- **sensors:** human-like, e.g. no lasers
 - cameras, microphones, gyros, encoders, force, tactile...



- **electronics:** flexibility for research
 - custom electronics, small, programmable (DSP)



- **reproducible platform:** community designed
 - reproducible & maintainable yet evolvable platform

why humanoids?



- scientific reasons
 - e.g. elephants don't play chess



- natural human-robot interaction



- challenging mechatronics



- fun!

why open platforms?



- repeatable experiments



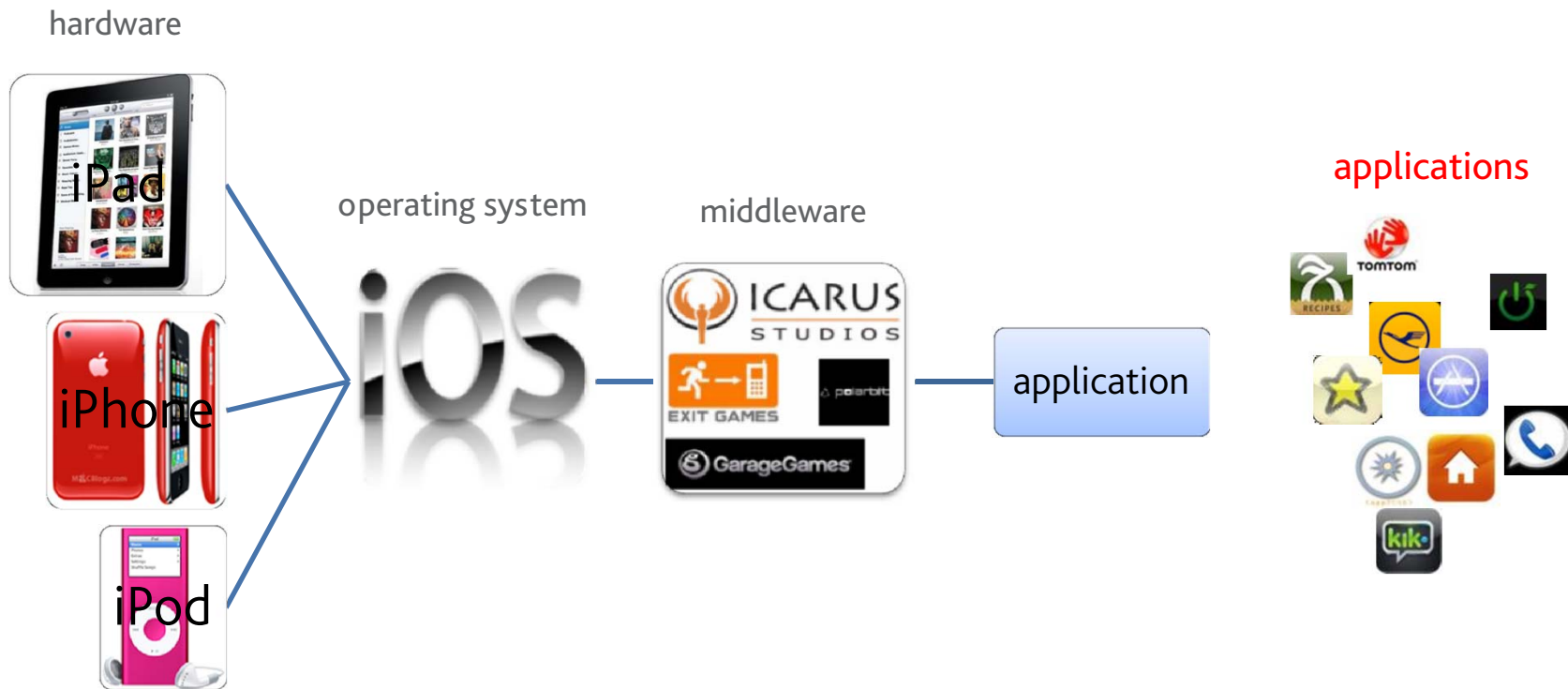
- benchmarking



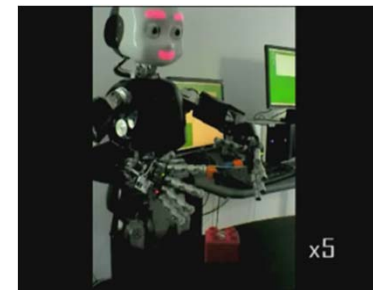
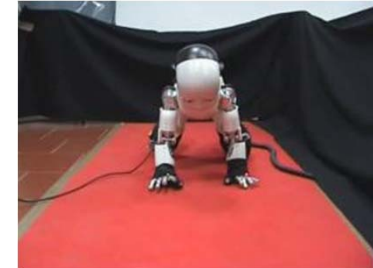
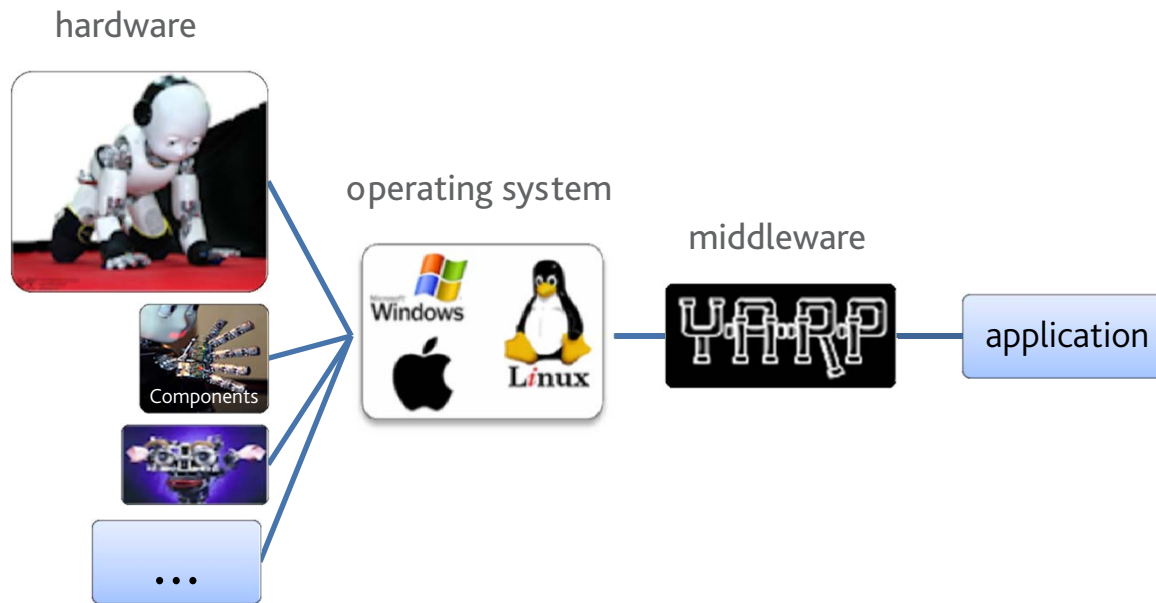
- quality

this resonates with **industry-grade R&D** in robotics

development tools (in the case of the iPhone)



development tools (in our case)



Yet Another Robot Platform

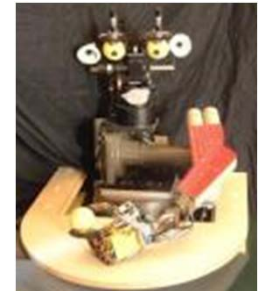
- YARP is an open-source (LGPL) middleware for humanoid robotics
- history
 - an MIT / Univ. of Genoa collaboration
 - born on Kismet, grew on COG, under QNX
 - with a major overhaul, now used by the iCub project
- C++ source code (some 400K lines)
- IPC & hardware interface
- portable across OSs and development platforms



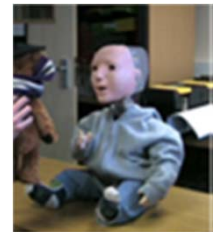
2000-2001



2001-2002



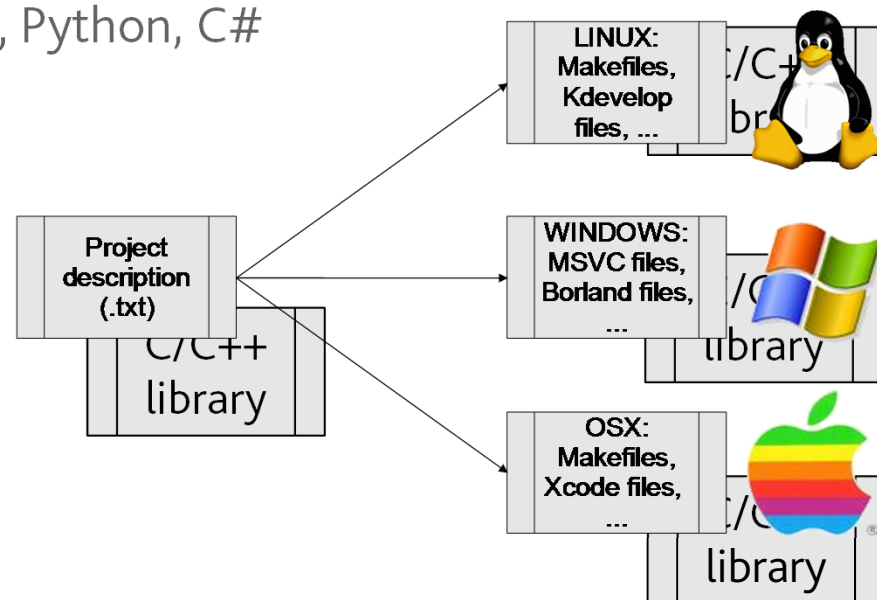
2003



2004-Today

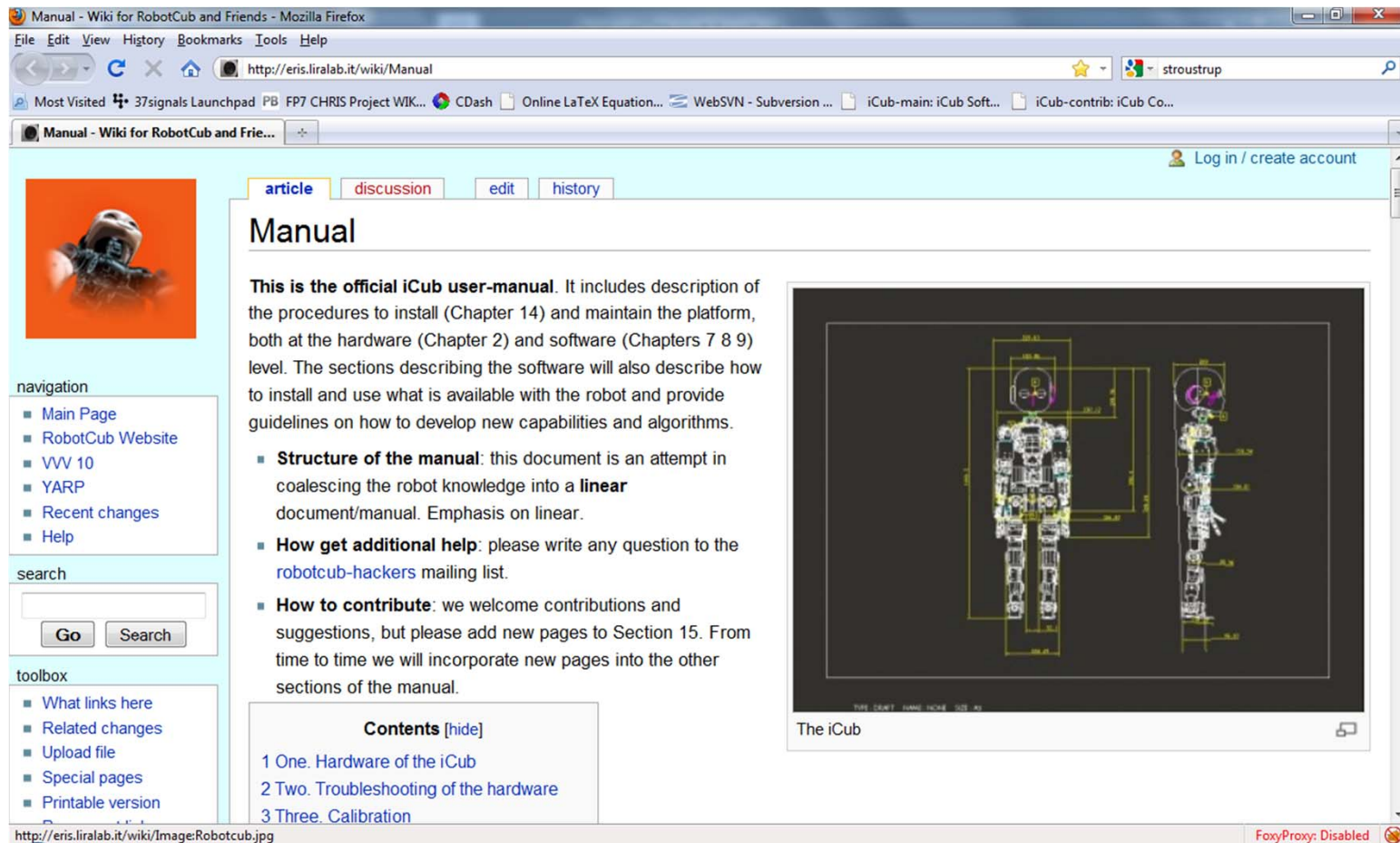
exploit diversity: portability

- operating system portability:
 - Adaptive Communication Environment , C++ OS wrapper: e.g. threads, semaphores, sockets
- development environment portability:
 - CMake
- language portability:
 - via Swig: Java (Matlab), Perl, Python, C#



The iCub online manual:

<http://icub.org> → iCub Manual



The screenshot shows a web browser window displaying the iCub online manual. The browser's address bar shows the URL <http://eris.liralab.it/wiki/Manual>. The page title is "Manual - Wiki for RobotCub and Friends". The page content includes a navigation sidebar on the left with links like "Main Page", "RobotCub Website", "VW 10", "YARP", "Recent changes", and "Help". The main content area features a large image of the iCub robot head and a detailed technical drawing of the robot's body with dimensions. The text describes the manual's purpose and provides instructions on how to get additional help and contribute to the project.

Manual

This is the official iCub user-manual. It includes description of the procedures to install (Chapter 14) and maintain the platform, both at the hardware (Chapter 2) and software (Chapters 7 8 9) level. The sections describing the software will also describe how to install and use what is available with the robot and provide guidelines on how to develop new capabilities and algorithms.

- Structure of the manual:** this document is an attempt in coalescing the robot knowledge into a **linear** document/manual. Emphasis on linear.
- How get additional help:** please write any question to the [robotcub-hackers](#) mailing list.
- How to contribute:** we welcome contributions and suggestions, but please add new pages to Section 15. From time to time we will incorporate new pages into the other sections of the manual.

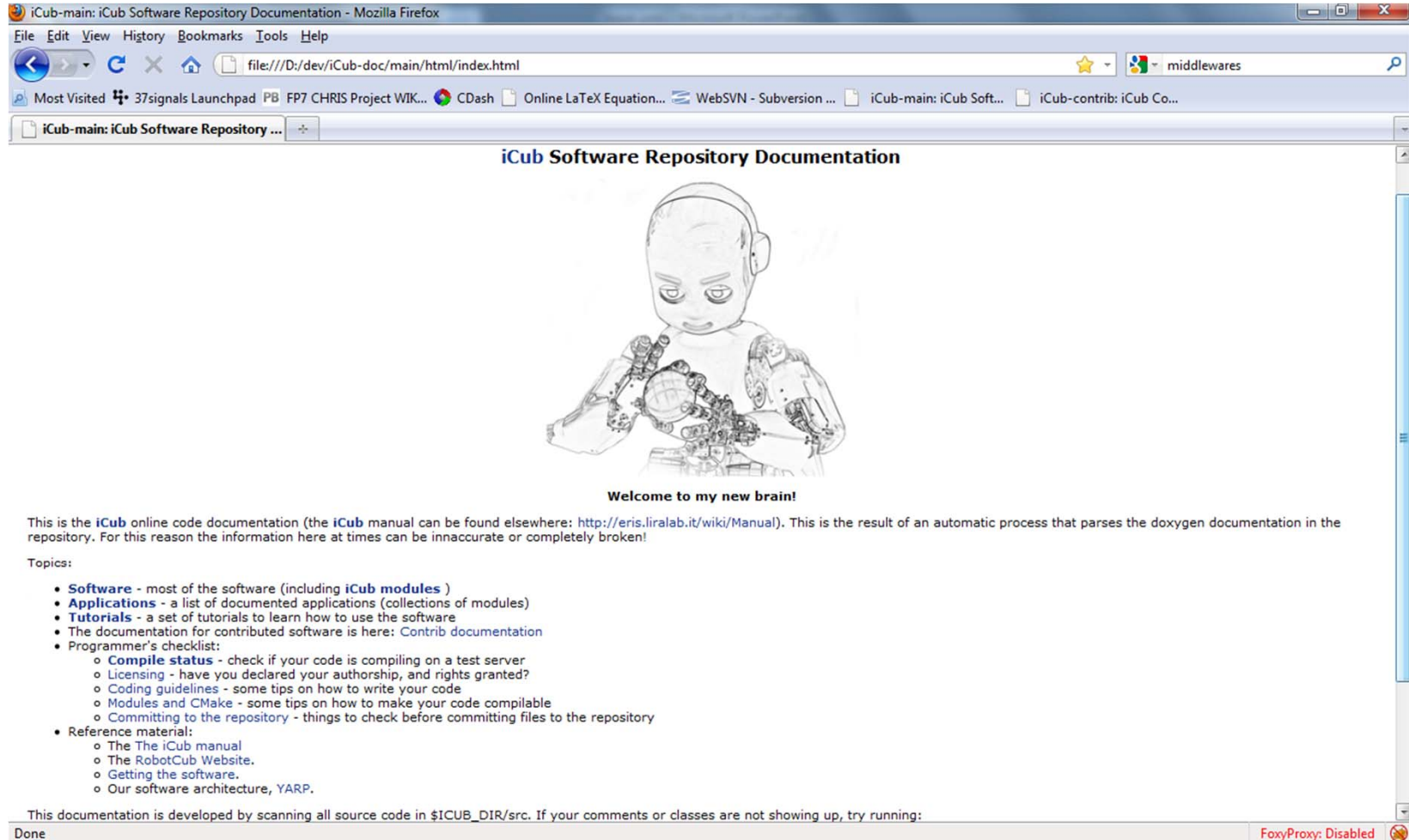
Contents [hide]

- One. Hardware of the iCub
- Two. Troubleshooting of the hardware
- Three. Calibration

The iCub

Software documentation:

<http://icub.org> → iCub software



iCub Software Repository Documentation

Welcome to my new brain!

This is the **iCub** online code documentation (the **iCub** manual can be found elsewhere: <http://eris.liralab.it/wiki/Manual>). This is the result of an automatic process that parses the doxygen documentation in the repository. For this reason the information here at times can be inaccurate or completely broken!

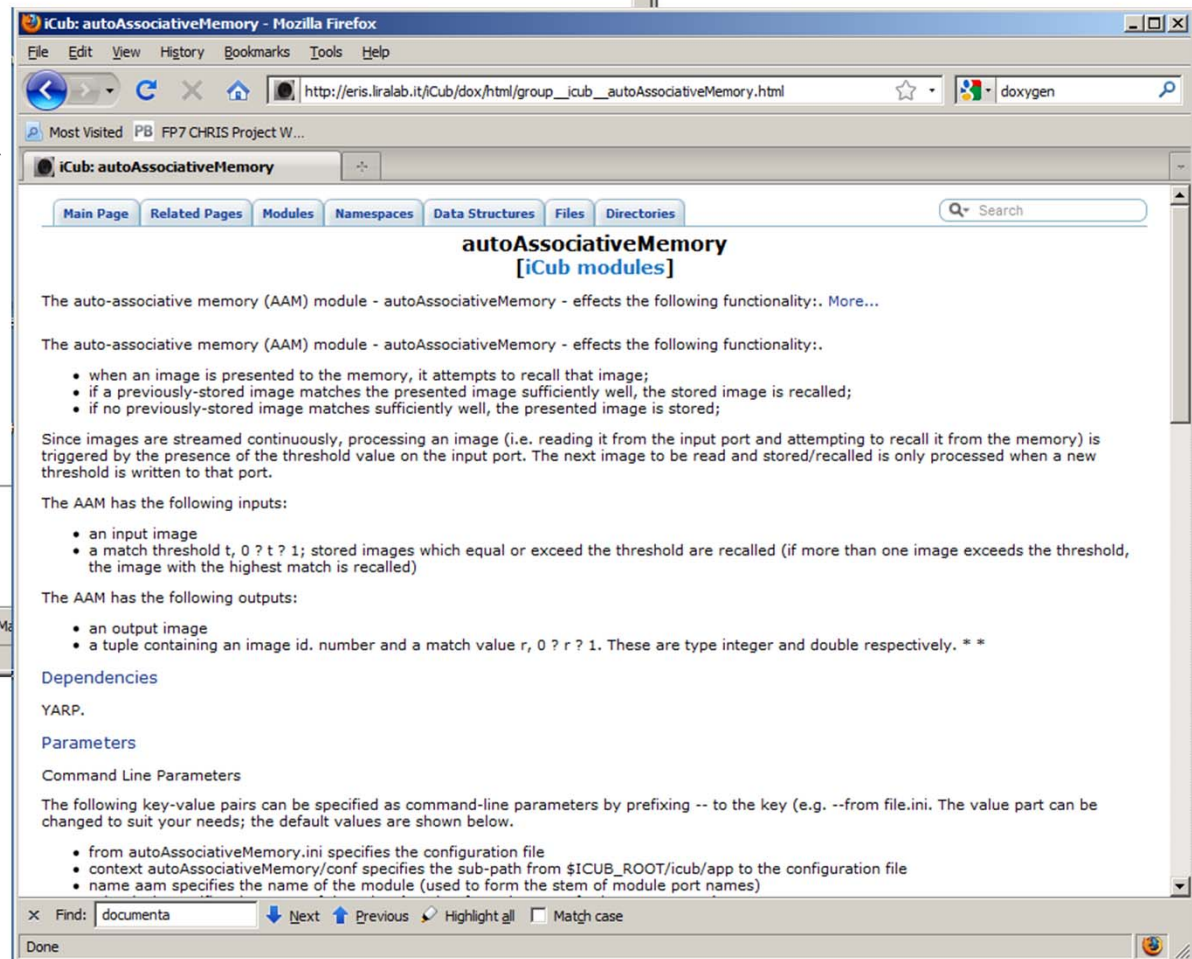
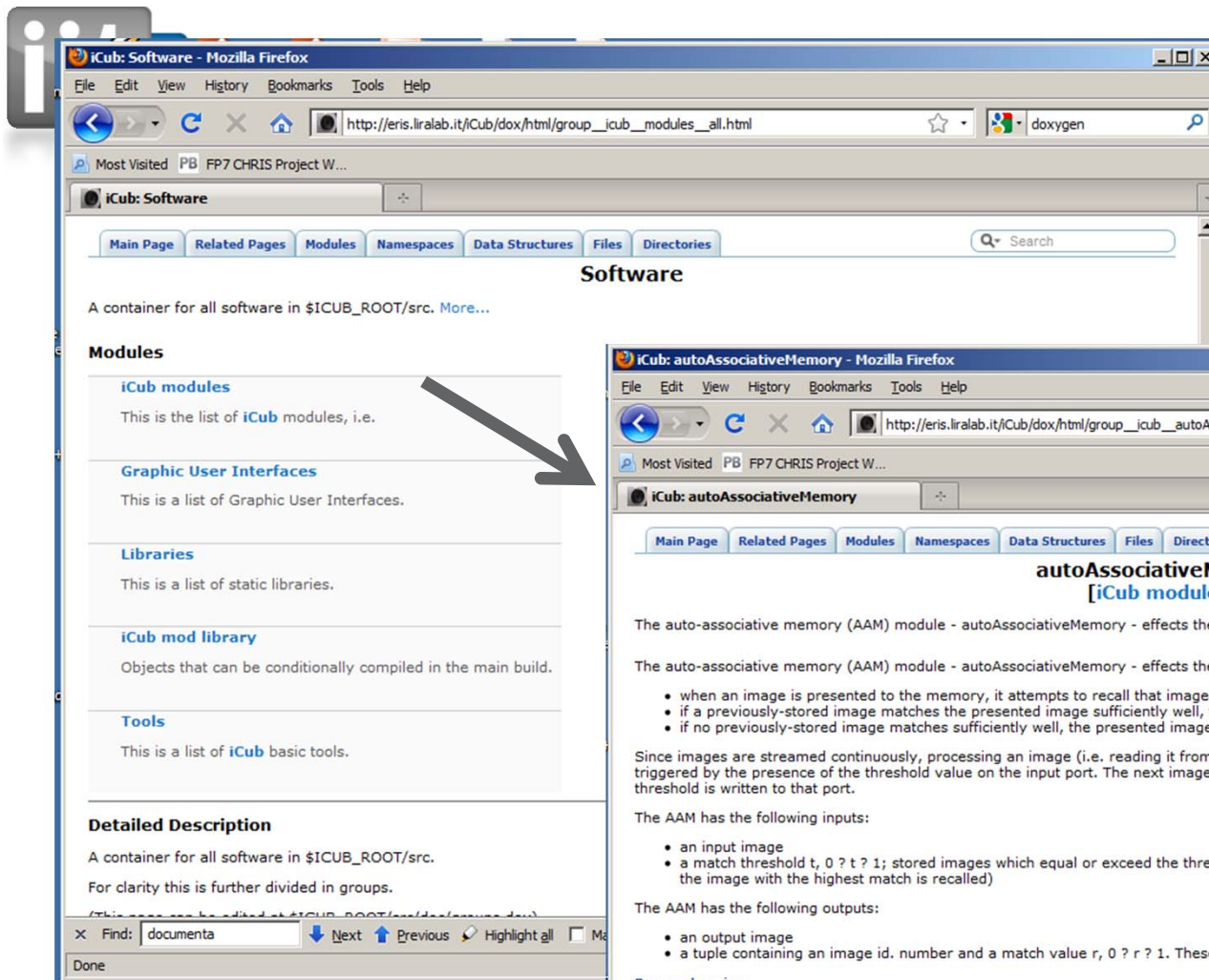
Topics:

- **Software** - most of the software (including **iCub modules**)
- **Applications** - a list of documented applications (collections of modules)
- **Tutorials** - a set of tutorials to learn how to use the software
- The documentation for contributed software is here: [Contrib documentation](#)
- Programmer's checklist:
 - **Compile status** - check if your code is compiling on a test server
 - **Licensing** - have you declared your authorship, and rights granted?
 - **Coding guidelines** - some tips on how to write your code
 - **Modules and CMake** - some tips on how to make your code compilable
 - **Committing to the repository** - things to check before committing files to the repository
- Reference material:
 - The **iCub** manual
 - The **RobotCub Website**.
 - Getting the software.
 - Our software architecture, **YARP**.

This documentation is developed by scanning all source code in `$ICUB_DIR/src`. If your comments or classes are not showing up, try running:

Done

FoxyProxy: Disabled





iCub: Applications - Mozilla Firefox

File Edit View History Bookmarks Tools Help

http://eris.liralab.it/iCub/dox/html/group_icub_applications.html

Most Visited PB FP7 CHRIS Project WIK...

iCub: Applications

Main Page Related Pages Modules Namespaces Data Structures Files Directories

Search

Applications

\$ICUB_ROOT/app/ stores directories which group sets of configuration files and scripts to run a certain group of modules together. [More...](#)

Modules

[armCartesianController](#)

An application that enables the user to select objects lying on a table, in order to steer the robot gaze to them and ultimately command a grasp.

[attentionDistributed](#)

This is the application used to run the attention system, distributed across the robot's sensors.

[cartesianSolver](#)

The Cartesian Solvers Launcher.

[crawlingDemo](#)

A set of modules for crawling and reaching on all fours.

[crossPowerSpectrumVergence](#)

Starts the crossPowerSpectrumVergence module.

[default](#)

Place here default configuration files and scripts.

[demoAAM](#)

Done

iCub: crawlingDemo - Mozilla Firefox

File Edit View History Bookmarks Tools Help

http://eris.liralab.it/iCub/dox/html/group_icub_Crawling.html

Most Visited PB FP7 CHRIS Project WIK...

iCub: crawlingDemo

Main Page Related Pages Modules Namespaces Data Structures Files Directories

Search

crawlingDemo [Applications]

A set of modules for crawling and reaching on all fours. [More...](#)

A set of modules for crawling and reaching on all fours.

Description

The Crawling application consists of a set of modules that are used for crawling, steering and reaching on all fours (please refer to [Deliverable 3.8](#) for more information). The architecture can be extended to visually guided crawling.

The general implementation for the basic crawling architecture is pictured below

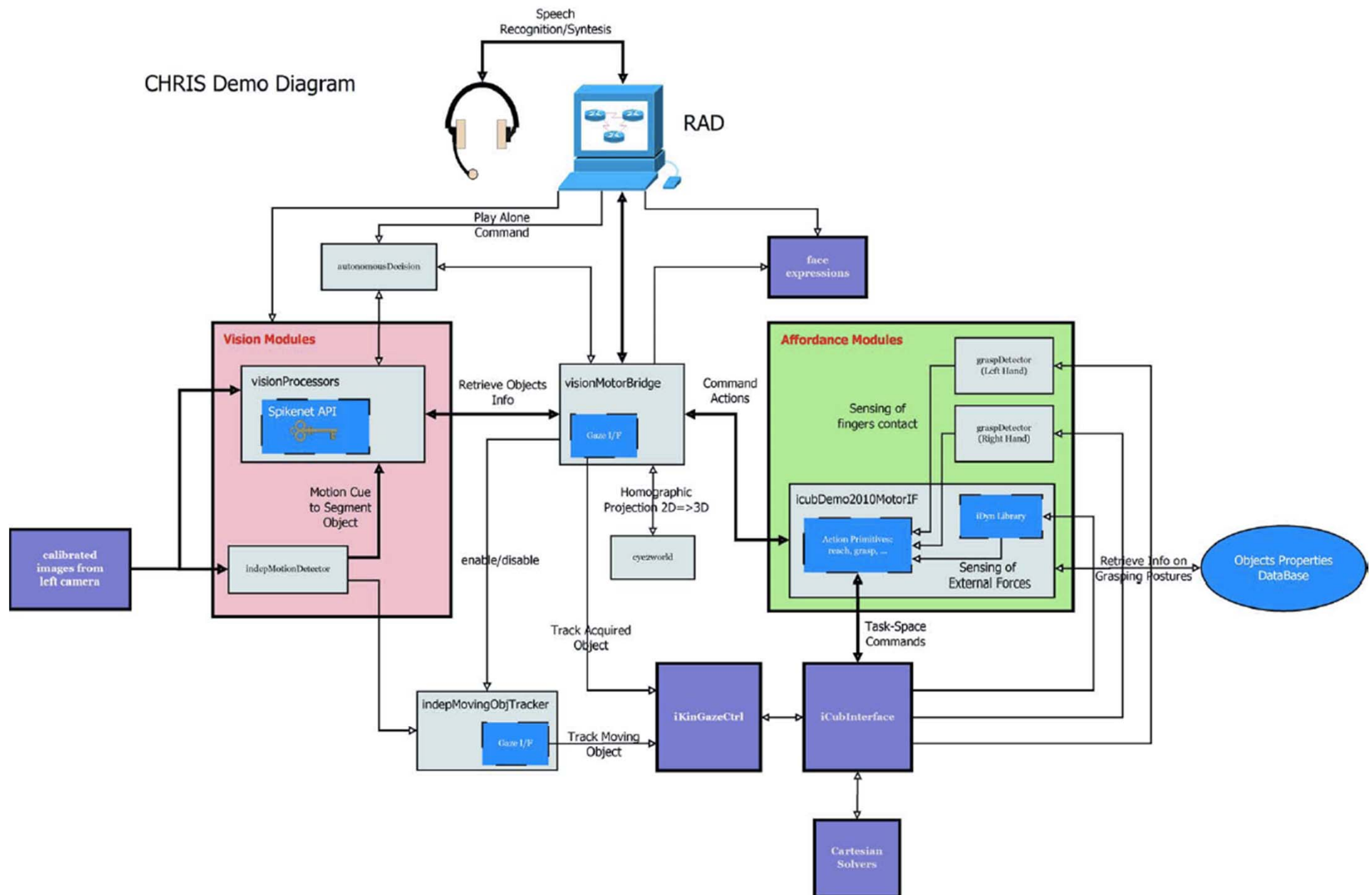
The four limbs as well as the head and the torso are controlled. For each part, the trajectories of all the dofs are produced by a **CrawlGenerator** module (referred to as CPG on the figure), some of them being coupled together to ensure the gait (green arrows). On top of these, the **CrawlManager** module is responsible for sending the control (i.e. high-level) parameters corresponding to the different behaviors.

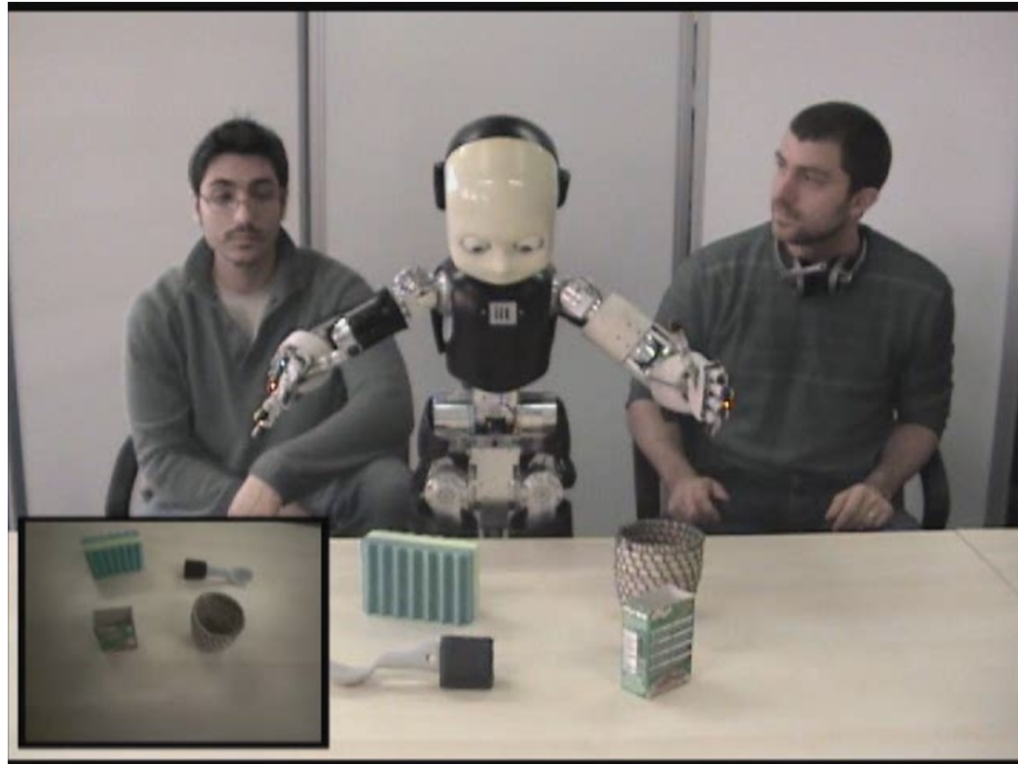
The behavior of the robot can be modulated by the user using the keyboard, more precisely :

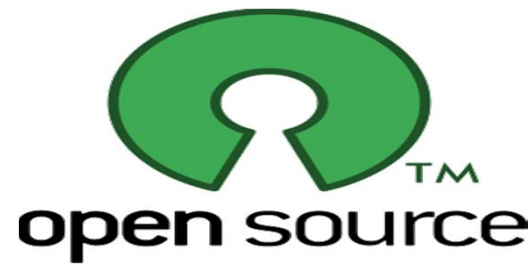
Find: icub Next Previous Highlight all Match case

Done

CHRIS Demo Diagram







article discussion edit history protect delete move watch

Manual

This is a tentative table of contents for what should be in the iCub manual. Please do not edit these pages at this point.

Contents [hide]

1. Hardware of the iCub
2. Troubleshooting of the hardware
3. Calibration
4. Protocols
5. Kinematic
6. Software, i
7. Software, c
8. Software, i
9. Software, i
10. Standard
- 11.11. Guidelin
- 12.12. Document

navigation

- Main Page
- RobotCub Website
- VW 07
- YARP
- Recent changes
- Help

search

Go Search

toolbox

- What links here
- Related changes
- Upload file
- Special pages
- Printable version
- Permanent link

1. Hardware

1. Parts a
2. Brushle
3. DC mot
4. Controll
5. Motorol
6. Camera
7. Gyros
8. CAN bu
9. Quad-C
10. Holl-off

TCL is available, shell is enabl

For Help, press F1

ssh:ssh

Ready

wiki

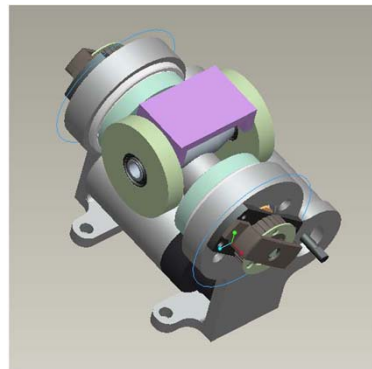
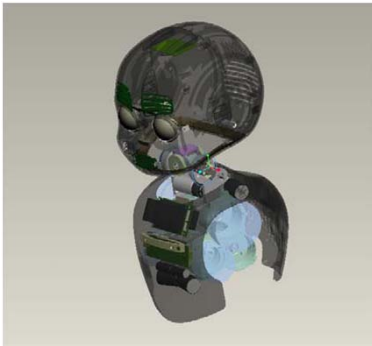
SVN

part lists

drawings

the entire project is under LGPL/GPL/FDL

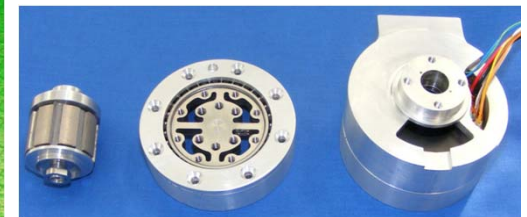
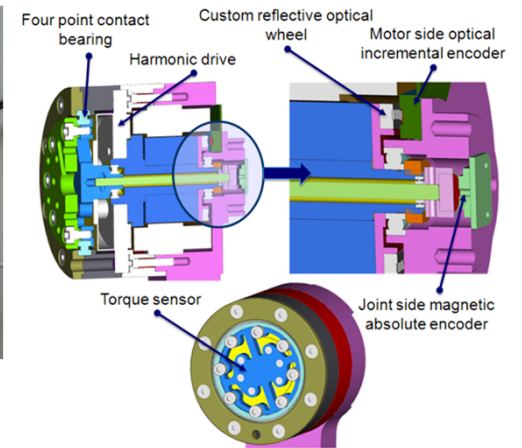
iCub 2.0 sneak preview



new mechanics



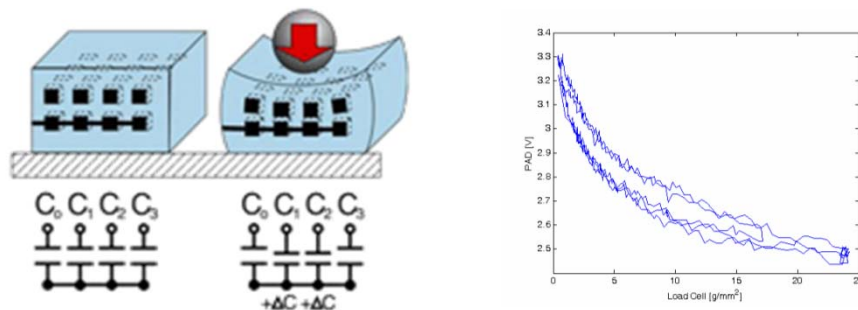
compliant actuators



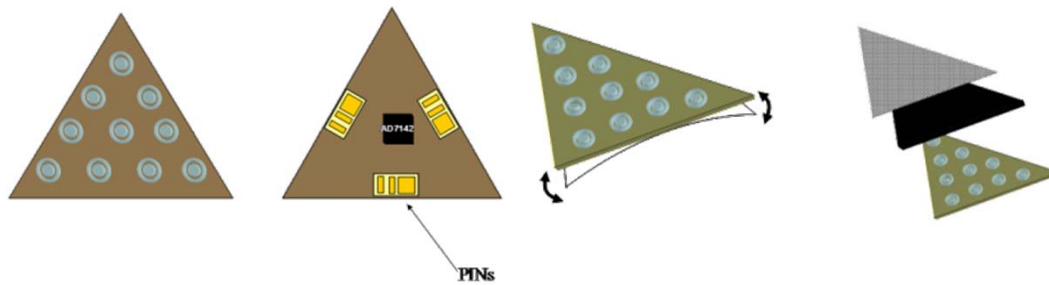
force/torque measurements

skin

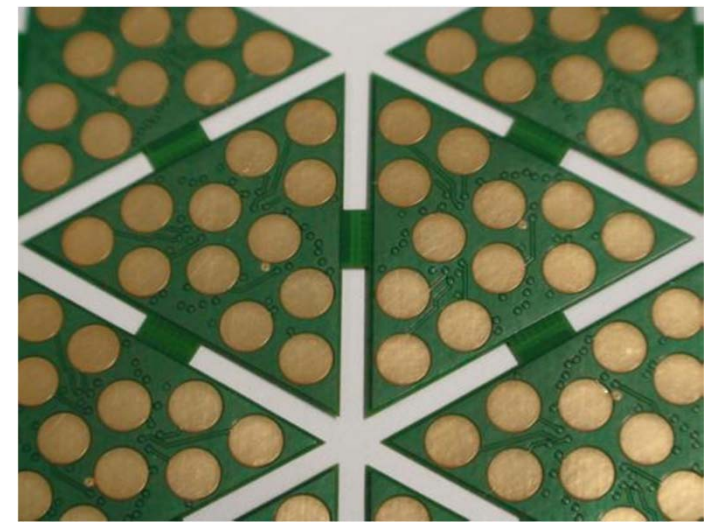
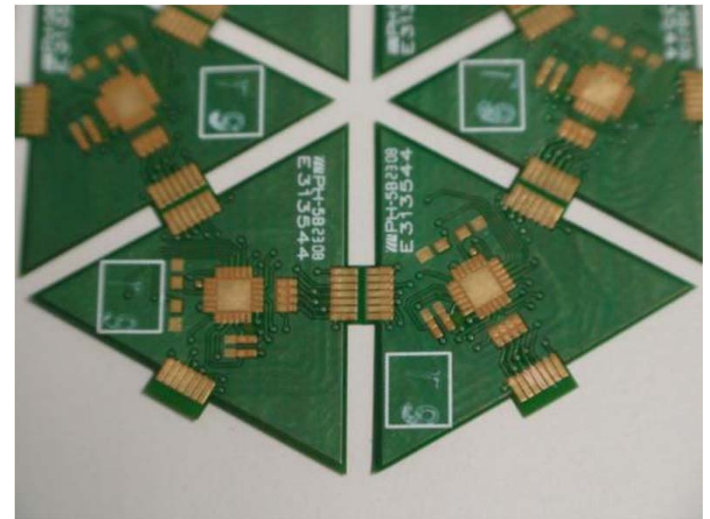
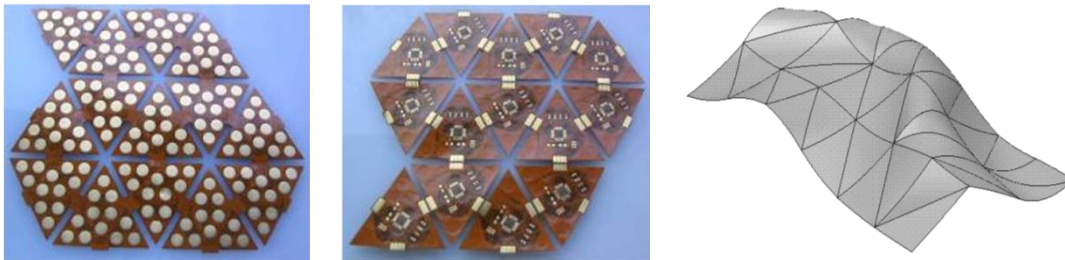
principle



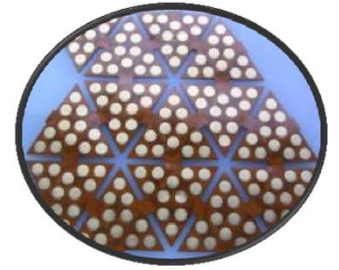
lots of sensing points



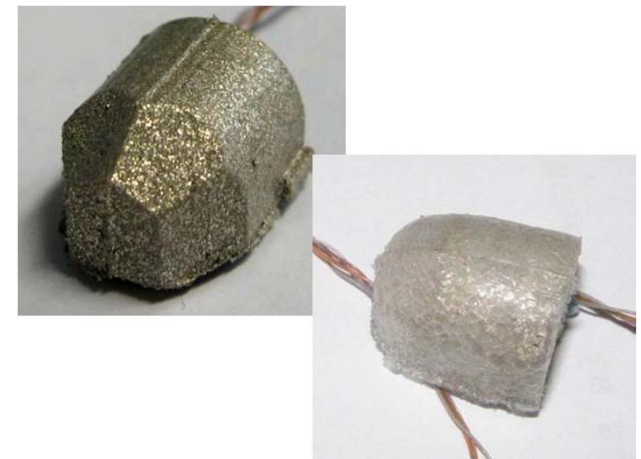
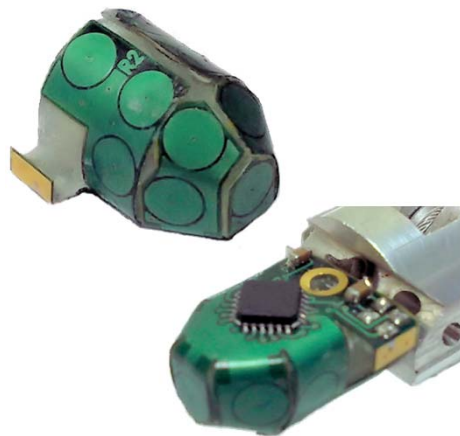
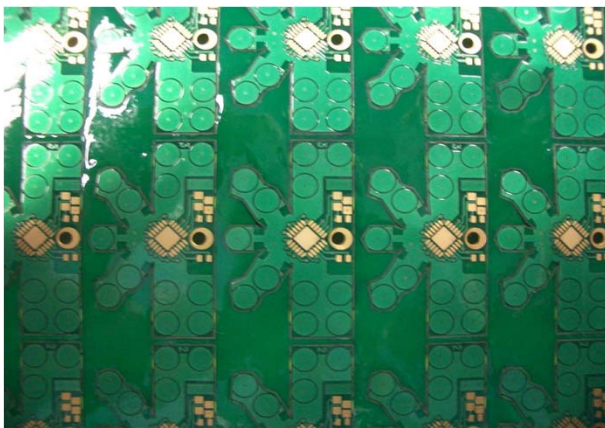
structure of the skin

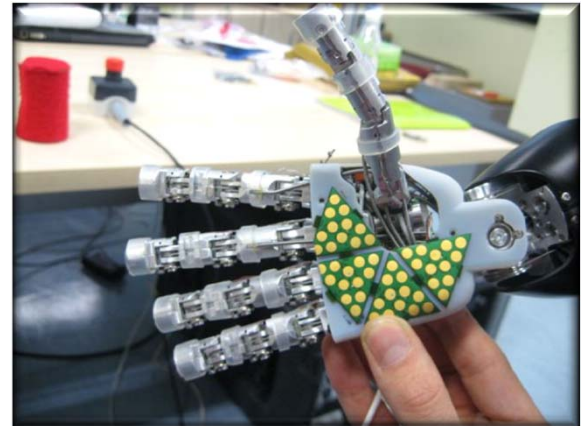
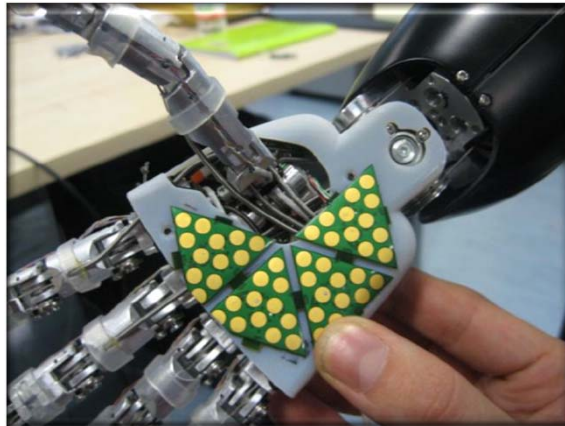
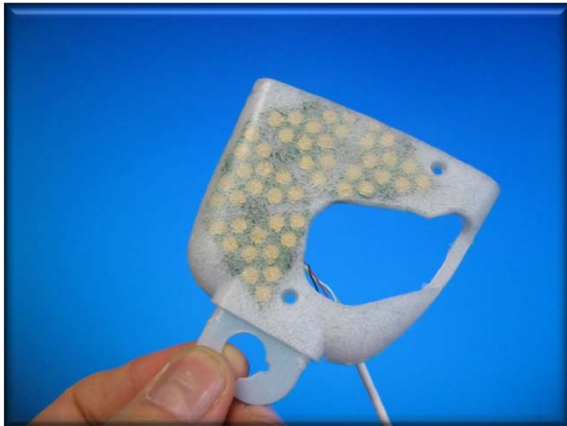
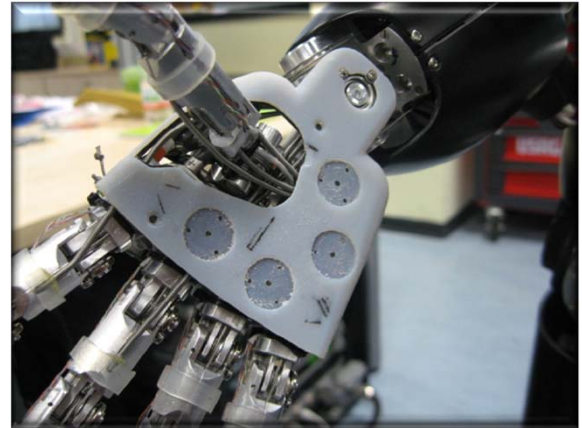
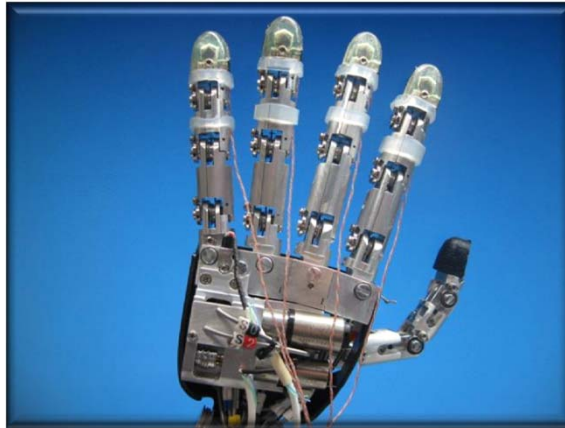
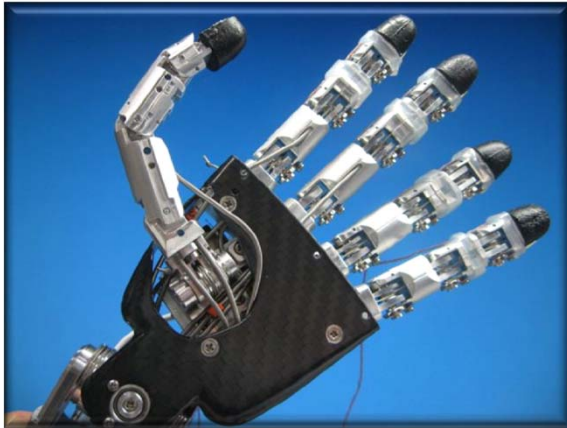


fingertips

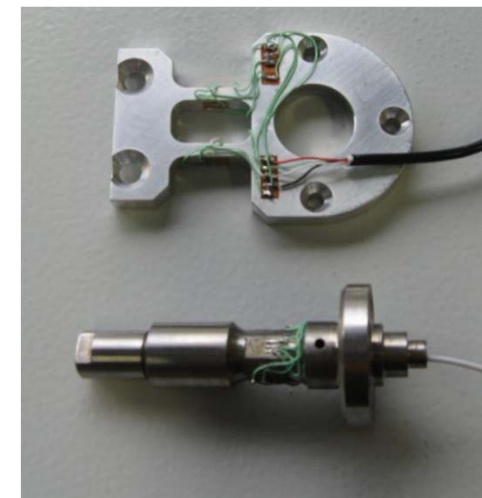
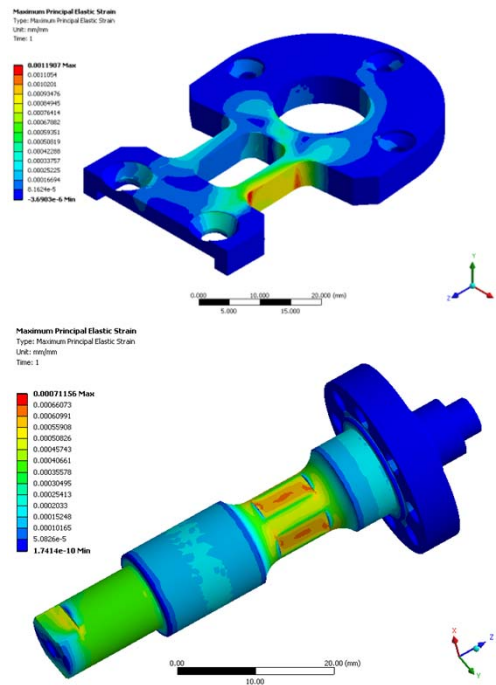


- capacitive pressure sensor with 12 sensitive zones
- 14.5 mm long and 13 mm wide, sized for iCub
- embedded electronics: twelve 16 bit measurements of capacitance
 - either all 12 taxels independently at 50 Hz or an average of the 12 taxels at about 500 Hz

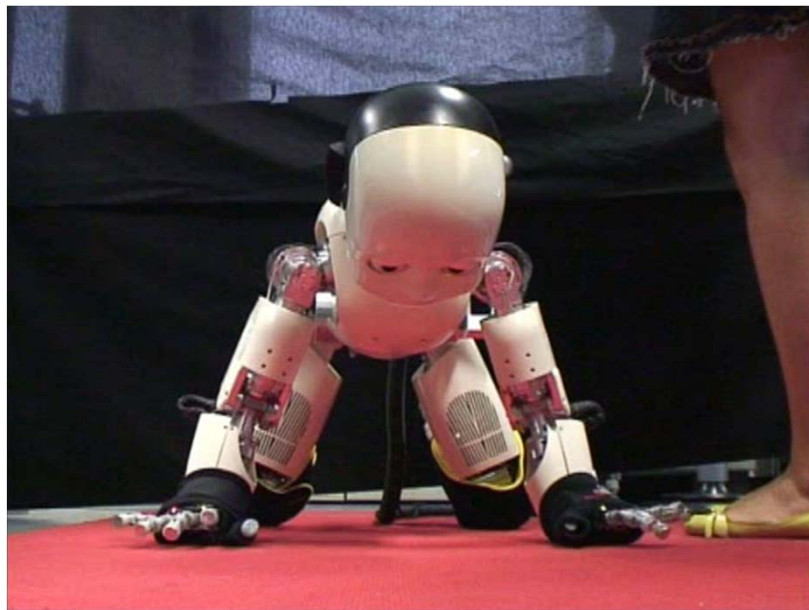
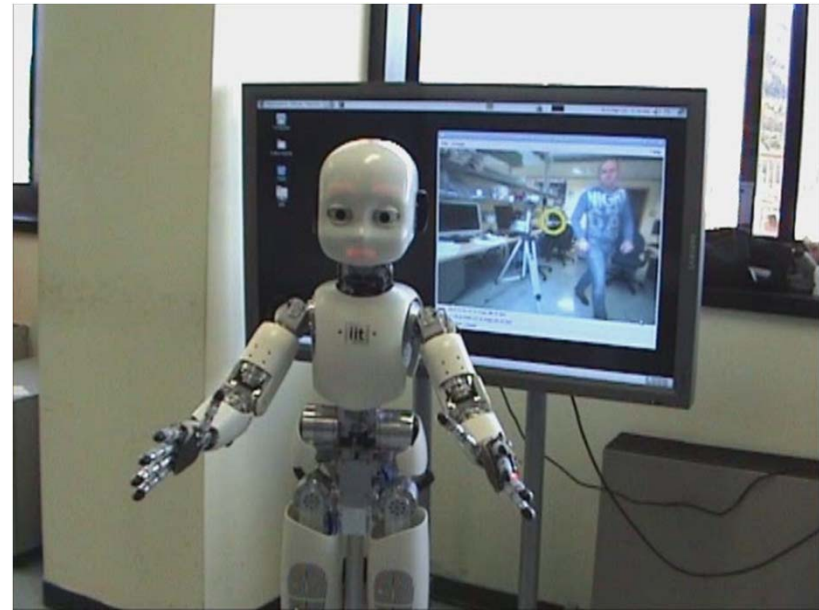
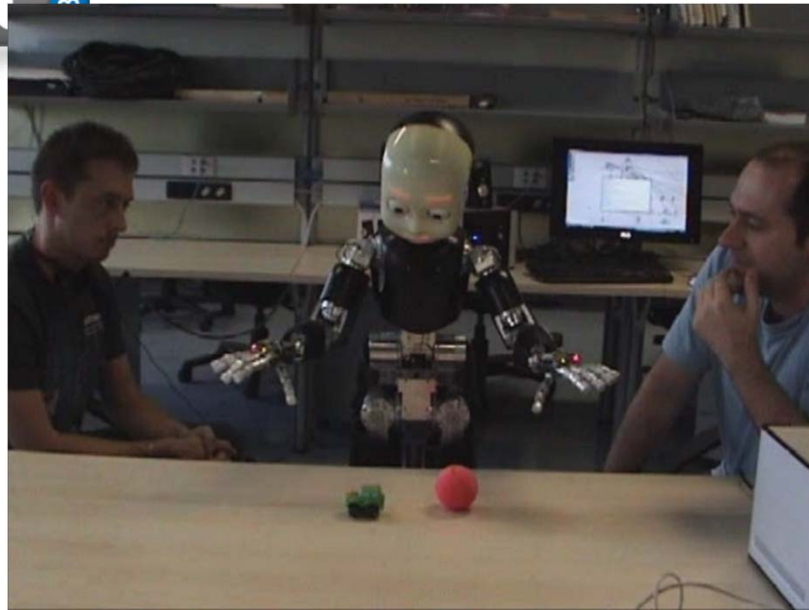




joint torque sensors



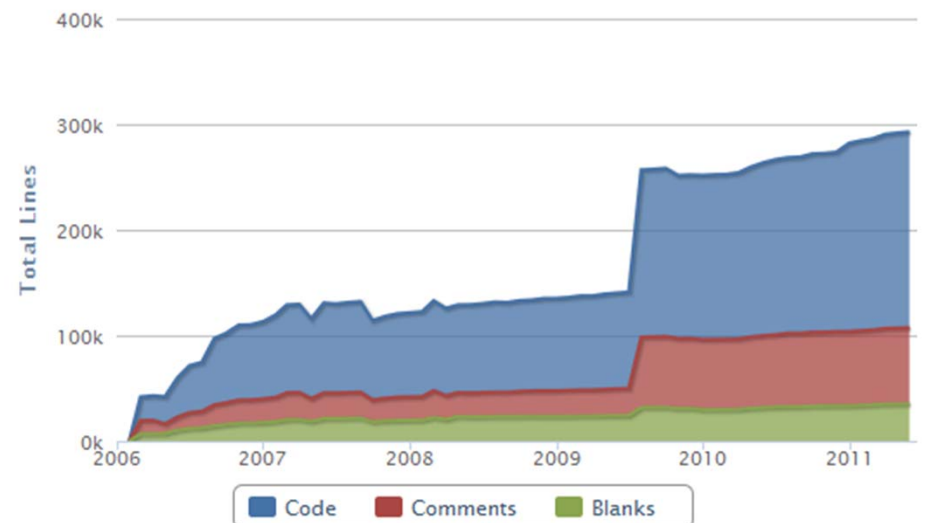




learning new actions

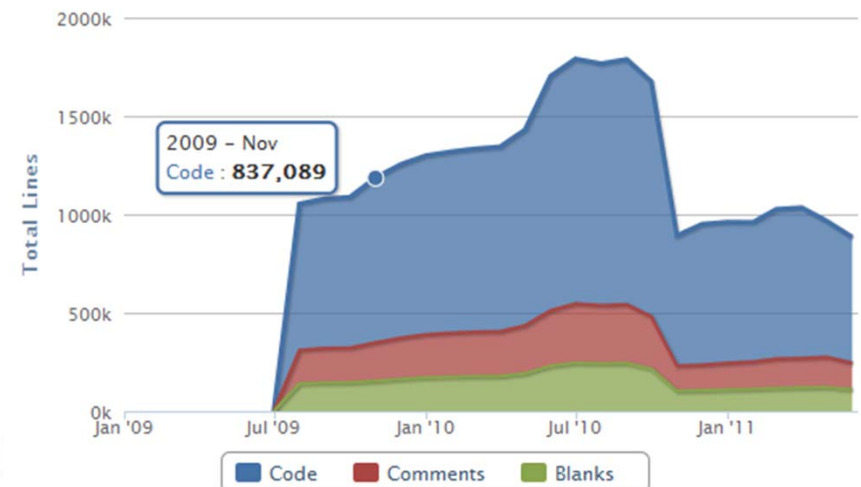
YARP progress (past year)

- Major rewrite of the **build system** using newer CMake features
- Official support for **MacOS**
- Bug fix, support
- **New test system** using CTest: <http://dashboard.icub.org>
- RPC client servers classes
- Persistent nameserver
- **Compatibility with other system** (e.g. ROS protocol)
- Change of licensing from GPL to **LGPL**
- **Port authentication** mechanism using HMAC with SHA
- **Binaries**, yes, eventually!



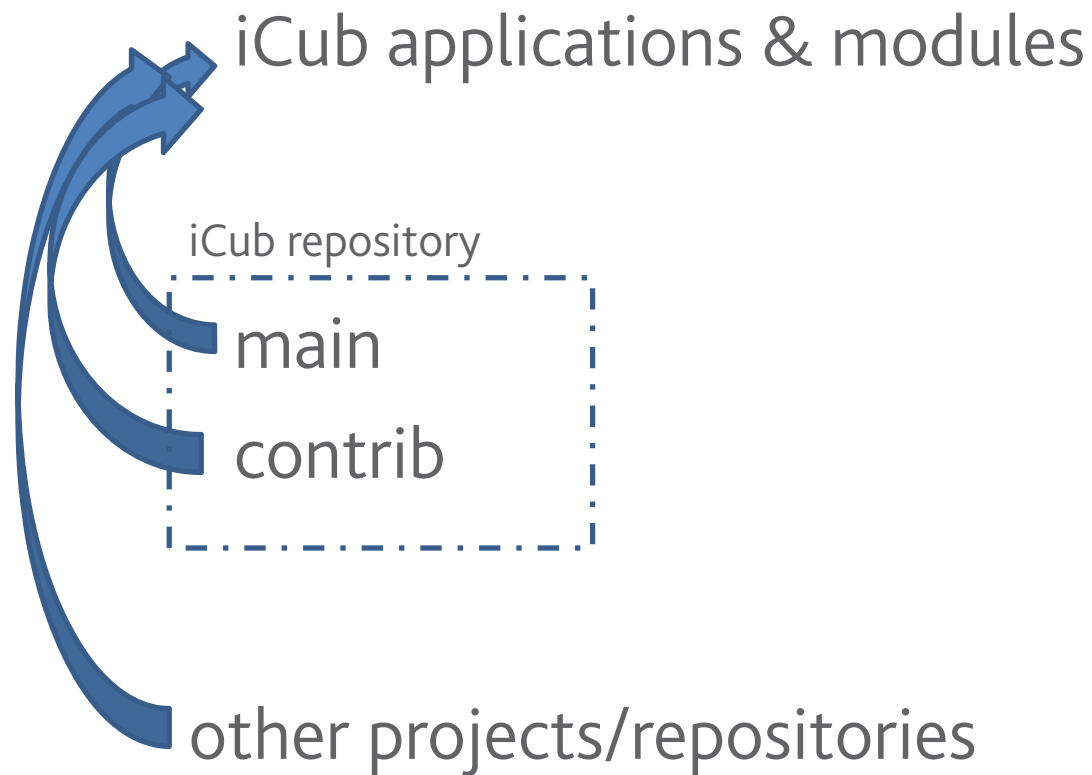
iCub progress (past year)

- Better **coexistence with external projects**
 - Now possible to use the iCub software as a CMake package
 - Separation between “main” and “contributed” software
- Support for new hardware (torque sensors, skin, new canbus device)
- **New modules** (force control, machine learning, inverse kinematics, logpolar attention system)
- Bug fixes and support
- Constant improvement of the manual and documentation
- Make **installation easier**: binaries of dependencies for windows
- New test system: <http://dashboard.icub.org>
- Work in progress:
 - better usability, gui, new simulator
 - **binaries**



New installation procedure

Scalability: coexistence with other projects



EU project repositories using svn externals to connect to iCub main/contrib

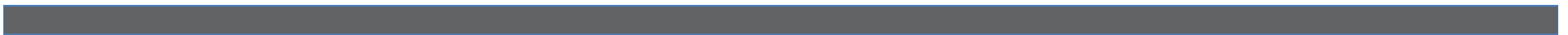
...why is this important?



Publish or perish

- Successful researchers learn to maximize the number of published papers
- **Loss of work and knowledge**
 - code is lost
 - “implementation details” get lost

...but maybe the “implementation details” are what
made the algorithm work!



Some questions

- How much time does it take to implement an algorithm from a paper? Does it always work?
- How difficult it is to choose the algorithms that work best?





Serious problems



Serious problems

- Lack of reward for producing reusable code





Serious problems

- Lack of reward for producing reusable code
- No mechanism for promoting successful software components



Serious problems

- Lack of reward for producing reusable code
- No mechanism for promoting successful software components
- Difficulty to compare experiments



Serious problems

- Lack of reward for producing reusable code
- No mechanism for promoting successful software components
- Difficulty to compare experiments
- No incremental progress



Serious problems

- Lack of reward for producing reusable code
- No mechanism for promoting successful software components
- Difficulty to compare experiments
- No incremental progress
- Our students tend to get stuck in “simple” problems

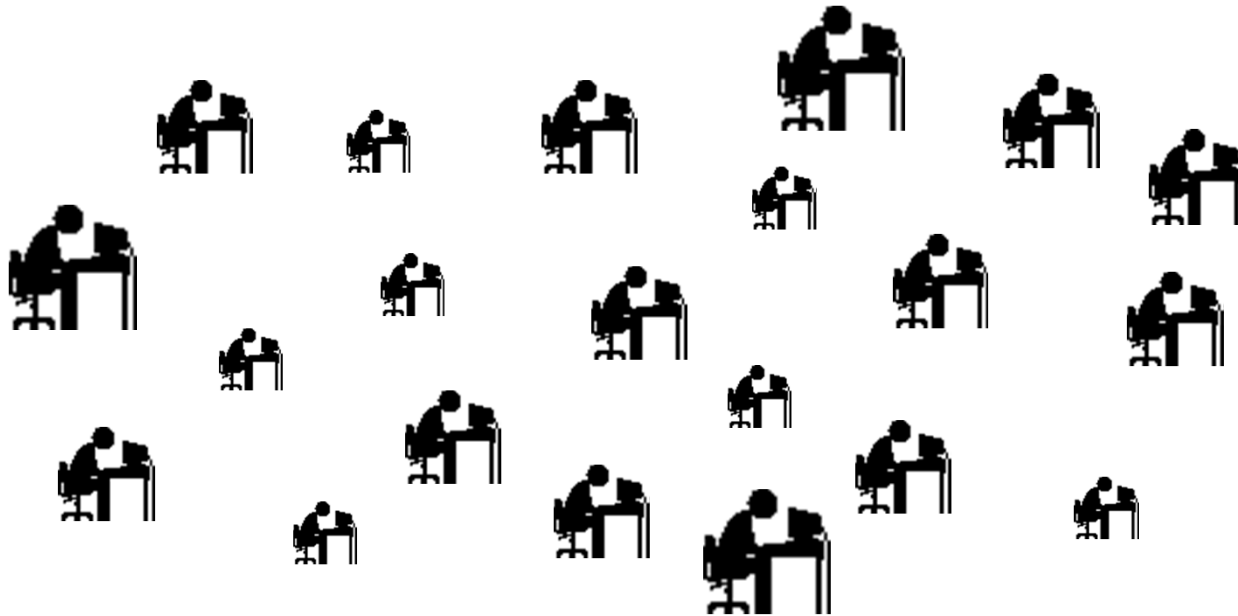




iCub community (snapshot at vvv10)



- 14 developers contributed code to YARP in the past 12 months
- 48 developers contributed code to iCub repository in the past 12 months



A new paradigm?

- Within the iCub community we have a great opportunity



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- See science as “what works”, peer usage as opposed to peer review



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- Don’t stop at experiments, think seriously about code development



A new paradigm?

- Within the iCub community we have a great opportunity
- See science as “what works”, peer usage as opposed to peer review
- Don’t stop at experiments, think seriously about code development
- **Publish** the code you write, make it **reusable**, write **documentation**





A new paradigm?

COMMIT or PERISH!!

Code Darwinism, the survival of the fittest code



source: www.ohloh.net



RobotCub - Ohloh - Mozilla Firefox

File Edit View History Bookmarks Tools Help

http://www.ohloh.net/p/6399/factoids/2296361

Most Visited PB FP7 CHRIS Project WIK... iCub: iCub Software R...

RobotCub - Ohloh

ohloh:Root

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RobotCub

Very large, active development team

Over the past twelve months, 29 developers contributed new code to RobotCub.

This is one of the largest open-source teams in the world, and is in the top 2% of all project teams on Ohloh.

GENERAL

- Summary
- Journal Entries
- Reviews
- Links
- News
- Managers
- Widgets

DEVELOPMENT

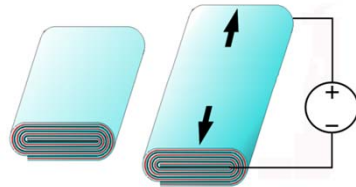
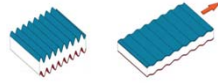
- Code Analysis

Find: demoAff2 Next Previous Highlight all Match case Phrase not found

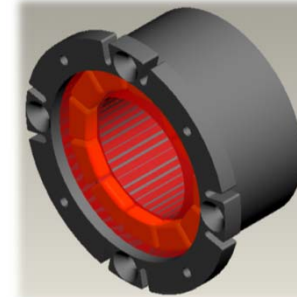
...one of the largest open source teams in the world, it ranks in the top 2% of all projects teams registered on Ohloh



more challenges for the future



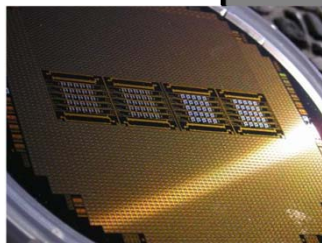
new actuation?



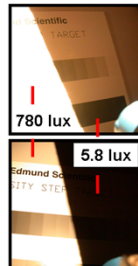
In collaboration with
our industrial partner



Contrast sensitivity under wide illumination.

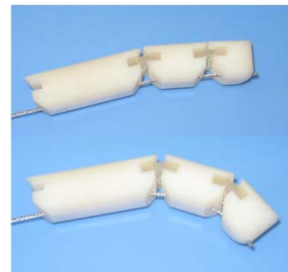


lux : 5.8 lux

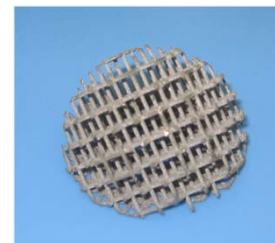


Edmund 0.1 density chart
Illumination ratio=135:1

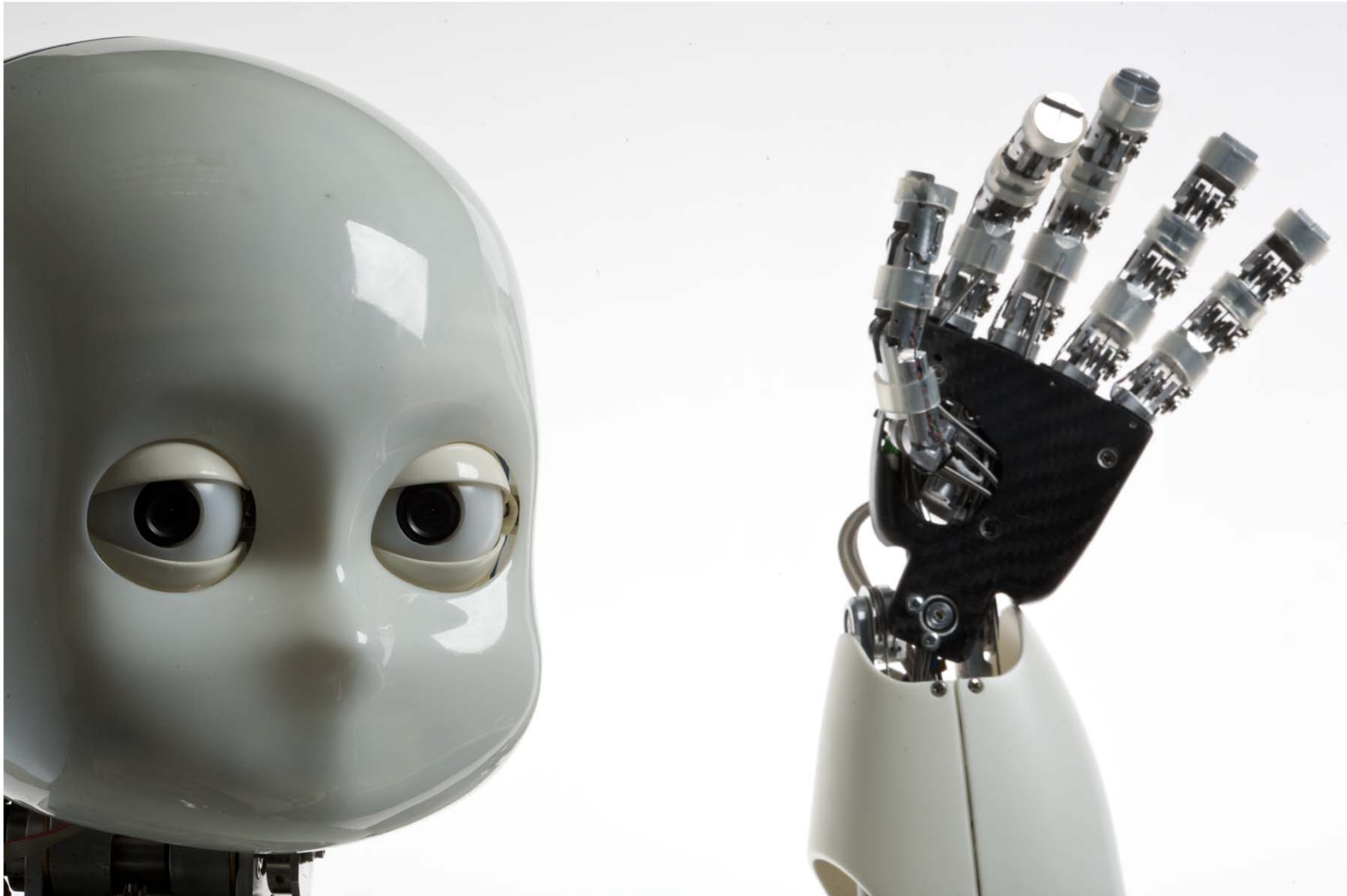
new sensors?



new materials?



maybe robotics is next



sponsors

- EU Commission projects:
 - RobotCub, grant FP6-004370,
<http://www.robotcub.org>
 - CHRIS, grant FP7-215805,
<http://www.chrisfp7.eu>
 - ITALK, grant FP7-214668,
<http://italkproject.org>
 - Poeticon, grant FP7-215843
<http://www.poeticon.eu>
 - Robotdoc, grant FP7-ITN-235065
<http://www.robotdoc.org>
 - Roboskin, grant FP7-231500
<http://www.roboskin.eu>
 - Xperience, grant FP7-270273
<http://www.xperience.org>
 - EFAA, grant FP7-270490
<http://efaa.upf.edu/>
- More information: <http://www.iCub.org>

